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GB 2159943 A GB 2069690 A WO 84/04876 A

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INT CL⁴ G01B, G01F, G01N
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(54) Determining a person's body density or fat level

(57) A person's density or fat content is determined by positioning the person at a point P between a light box 10 and a ligh intensity measuring device 12 e.g. a light meter, photometer or video camera and measuring the light intensity with the person standing in different orientations. This enables the volume of the person to be determined by a computer 20 and th density and fat content to be calculated in the computer from the measured volume and the measured weight of the persor In Figs 2 & 3 not shown one wall of a light tight cubicle forms the light source and the person stands on a platform providec with a load cell for weighing between the light source and a video camera.

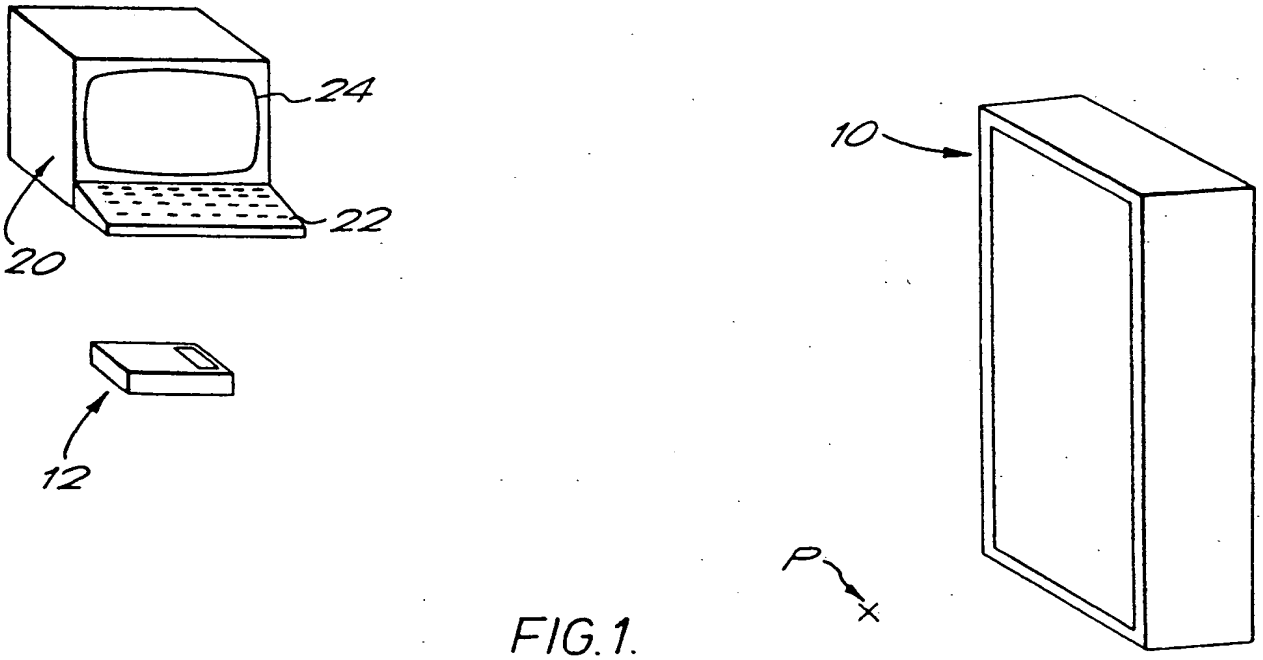


FIG. 1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

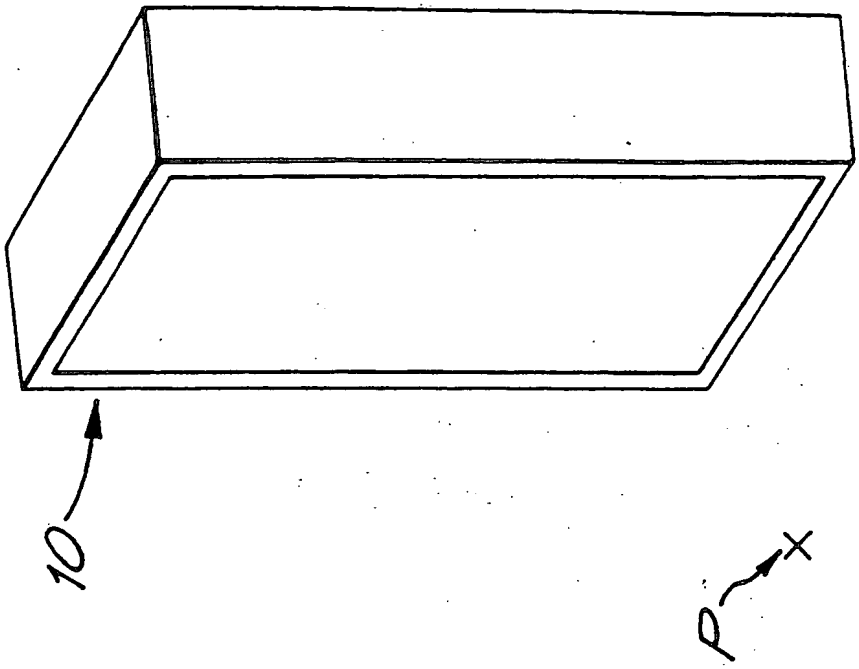
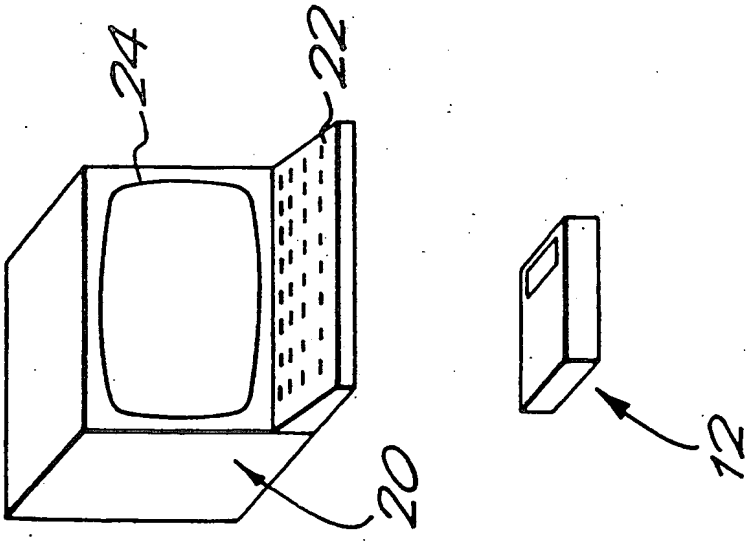


FIG.1.



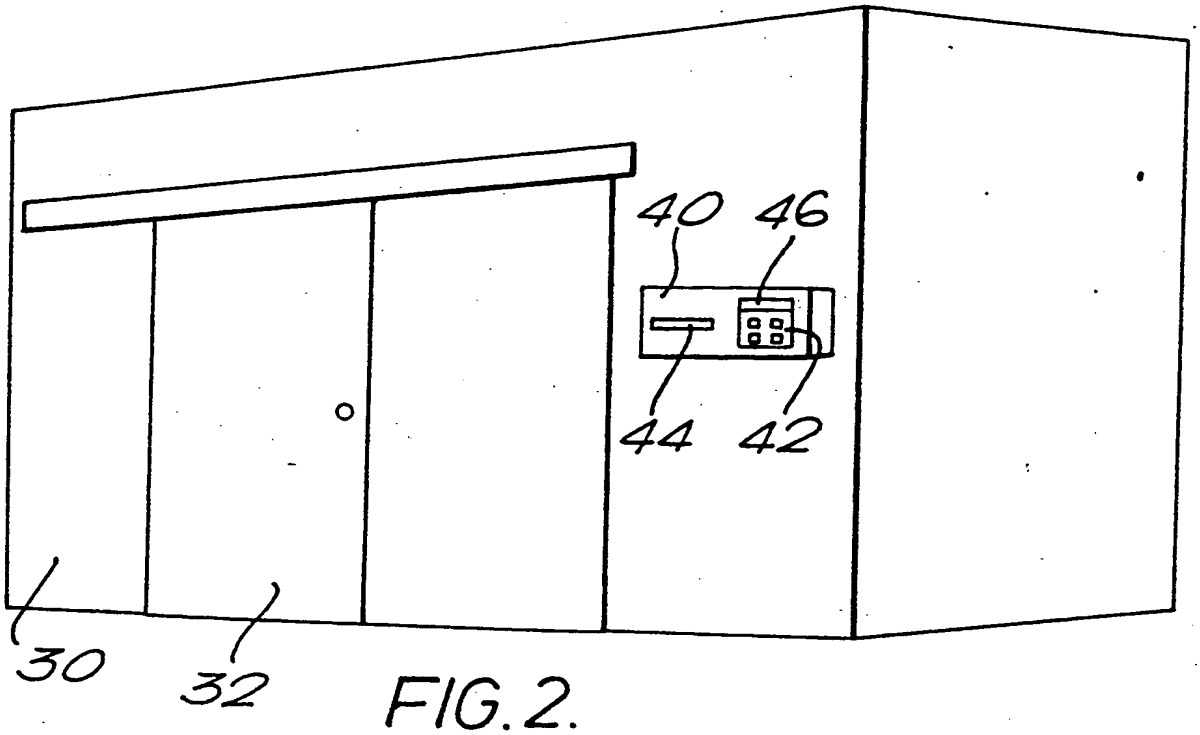


FIG. 2.

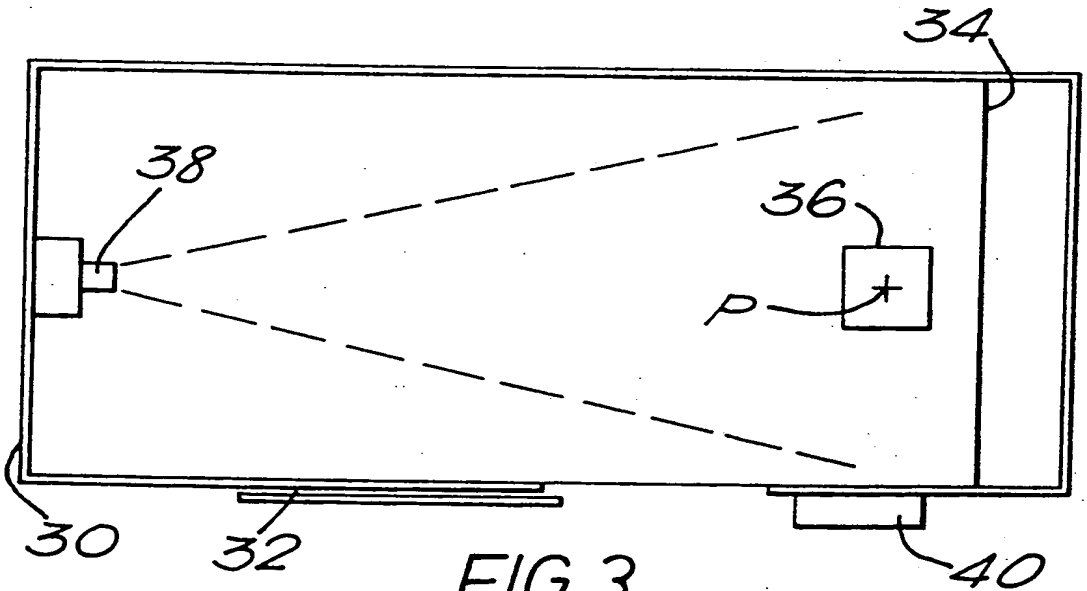


FIG. 3.

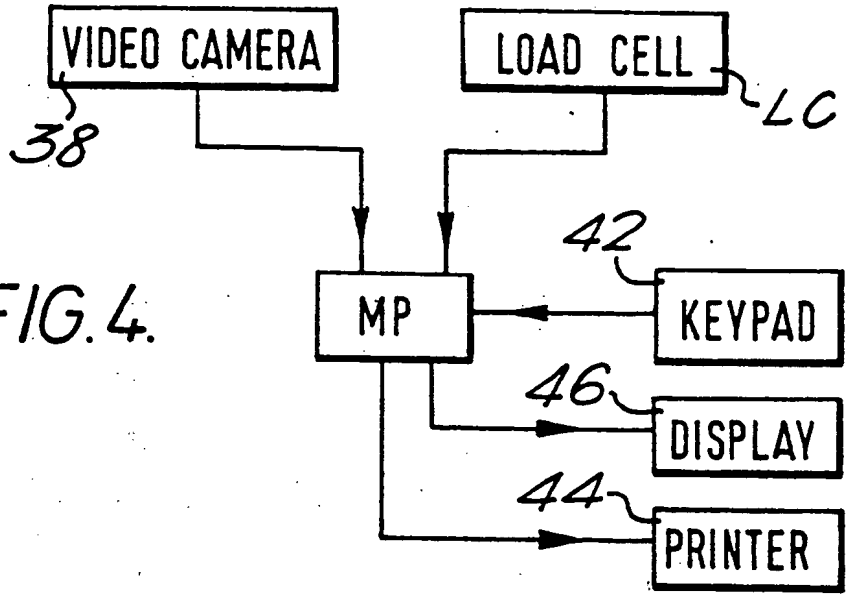

VIDEO CAMERA
38
LOAD CELL
LC
42
MP
KEYPAD
46
DISPLAY
44
PRINTER

FIG. 4.

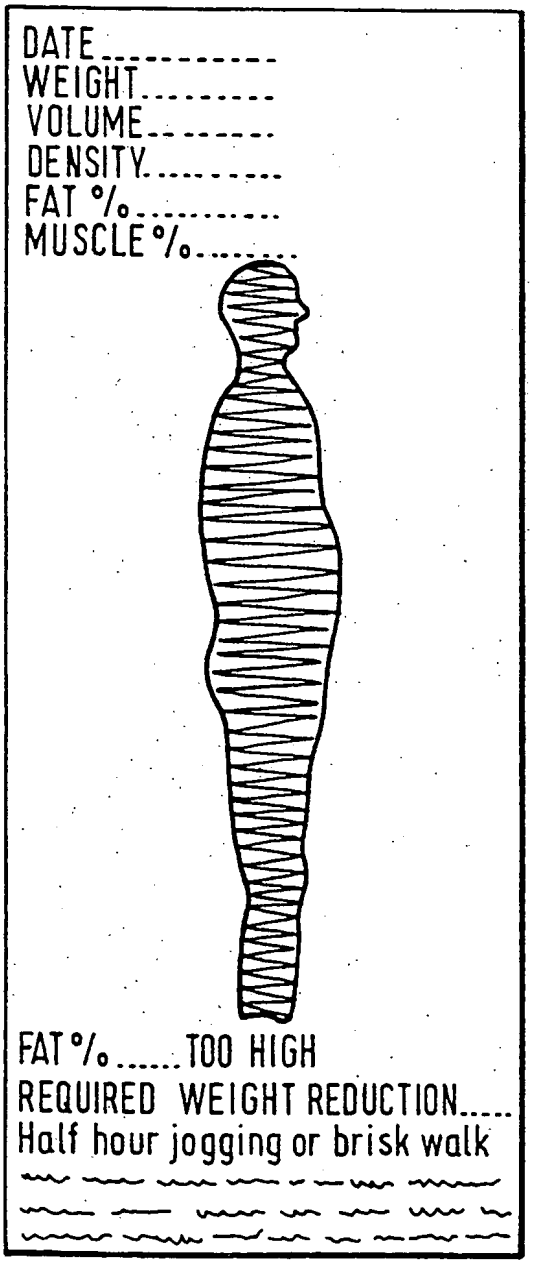

DATE.....
WEIGHT.....
VOLUME.....
DENSITY.....
FAT %.....
MUSCLE %.....
FAT %.....TOO HIGH
REQUIRED WEIGHT REDUCTION.....
Half hour jogging or brisk walk

FIG. 5.

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APPARATUS AND METHOD OF DETERMINING A PERSON'S BODY DENSITY OR FAT LEVEL

This invention relates to an apparatus and method for determining a person's body density or fat level.

Techniques are known for determining body fat for assessing people who might be overweight. However, these known techniques suffer from various drawbacks.

The commonest technique of measuring fat involves the use of a device in the form of a spring-loaded caliper which is used to pinch the skin and thus measure the thickness of subcutaneous fat. This technique is inaccurate because the measurement can only be taken at discrete points. Also, the technique is often objectionable to the subject because of the element of personal contact.

Another known way of determining overweight involves the use of standard tables of height to weight ratio. However, these tables are always compiled in respect of average people and do not take into account people with large bones or with high density due to well developed muscles.

A method of measuring body density comprises weighing the person in air and in water. However, this method is generally inconvenient and also is liable to inaccuracy owing to the buoyancy of air in the lungs when weighing the person in water.

Two other techniques for measuring fat thickness are ultrasonic imaging and computer aided tomography. However, the equipment needed for each of these techniques is extremely expensive.

I have now devised an apparatus and method for determining a person's body density or fat level, which overcomes the drawbacks of the techniques described above.

In accordance with this invention, there is provided an apparatus for determining a person's body density or fat level, comprising a light receiving device for directing at

fat level in accordance with the intensity of illumination received by said device.

In one form of the apparatus, a light source is provided and the light receiving device (e.g. a light meter) is directed at this light source. A reading or readings are taken with a person standing between the light source and light meter and preferably compared with a reading taken in the absence of the person.

Preferably the light source comprises a light box of sufficiently large area as to enable a complete silhouette of a person to be obtained and the light box should provide a substantially even intensity of illumination over its entire area.

Each reading of the light meter is proportional to the area of the person's silhouette, that is to say it is proportional to the cross-sectional area of the person's body. Successive readings may be taken as the person turns, then integrated so as to give a measure of the person's volume. Then by weighing the person the body density can be calculated and furthermore the percentage of fat can be calculated from the formula:

$$\text{Body fat \%} = (4.95/\text{Density} - 4.50) \times 100$$

The successive readings may be taken at three positions of the person, (a) facing sideways, (b) turned through 45° and (c) facing the light receiving device. If the three measurements A, B, C are plotted against angular position, then the volume of the person's body is the area under the curve ABC x 4.

More accurate measurements can be made by turning the person through 360° and recording the readings of the light meter and plotting them against angular position. The area under the curve is then proportional to the volume of the body.

A technique which is however sufficiently accurate under a wide range of conditions is to take one reading

on the light meter with the person standing sideways. Although this provides a reading of the cross-sectional area of the person's profile, this is usually related sufficiently accurately to the person's volume.

In an alternative aparatus, a video camera is directed at the subject who is illuminated from the rear with an opaque white screen. The video camera records the silhouette of the subject which is digitised by means of an analogue to digital converter and recorded in a computer memory. The computer then calculates the area of this image. By taking readings of this area as the subject turns in front of the screen the computer can then calculate the volume of the subject.

Also in accordance with this invention, there is provided a method of determining a person's body density or fat level, comprising directing a light receiving device at a person and determining the person's body density or fat level in accordance with the intensity of illumination received by said device.

Embodiments of this invention will now be described by way of examples only and with reference to the accompanying drawings in which:

FIGURE 1 is a schematic perspective view of an apparatus for determining a person's body density or fat level;

FIGURE 2 is a perspective view of another apparatus for determining a person's body density or fat level.

FIGURE 3 is a plan view of the inside of the cubicle of the apparatus of figure 2;

FIGURE 4 is a schematic block diagram of the electronic system of the apparatus shown in Figures 2 and 3; and

FIGURE 5 shows a printout which may be provided from the apparatus of Figures 2 and 3.

Referring to Figure 1 of the drawings, there is shown an apparatus for determining a person's body density or fat level, comprising a light box 10 and a light meter or photometer 12 spaced from but directed towards the light box and supported generally at waist-height. The light box is of

obtained of a person standing just in front of the light box, at the point P.

The apparatus further comprises a computer 20 with a keyboard 22 and a visual display unit 24. A printer may be provided instead of or in addition to the visual display unit 24.

In use, a reading is taken on the light meter with the person standing sideways in front of the light box, the reading therefore being related to the cross-sectional area of the person's profile. This reading is then keyed into the computer, together with a reading taken when nobody is interposed between the light meter and light box, and also the person's weight. The computer is programmed to calculate from the data the person's density and/or the person's percentage fat. These results are given on the visual display unit and/or by the printer.

Instead of the single reading taken with the person standing in front of the light box, successive readings can be taken with the person at different angular positions as described above. These readings are all keyed into the computer, which integrates the readings with respect to angular position to calculate a measure of the person's volume. One way of calibrating the apparatus is to hang a card of known area in front of the light box and then to take a reading on the light meter from which the computer calculates a volume corresponding to the volume of rotation of the card.

Referring to Figures 2 and 3 of the drawings, there is shown an alternative apparatus which uses a video camera directed at the subject. The apparatus comprises a cubicle 30 which is substantially light-tight and includes a sliding door 32 in its front for the subject to step through and into the cubicle. Within the cubicle and at one end there is a translucent panel 34 which is illuminated uniformily from behind, and of sufficiently large area so that a complete

silhouette can be obtained of a person standing just in front of the panel 34, at the point P.

A platform 36 is provided on the floor of the cubicle just in front of the panel 34, and a load cell is coupled to this platform. The point P at which the subject is required to stand is marked at the centre of the platform 36.

At the other end of the cubicle, a video camera 38 is mounted, approximately at waist height, and directed at the panel 34. The field of view of the video camera 38 includes the entire area of the panel 34.

The apparatus further includes a computer which is mounted in a housing 40 on the front wall of the cubicle alongside the entry doorway. Output signals from the load cell and from the video camera are passed to the computer. The housing 40 is provided with a keypad 42, with a printer 44 and with a visual display 46.

Figure 4 shows a block diagram of the electronic system of the apparatus of Figures 2 and 3. This system comprises a microprocessor MP receiving signals from the load cell LC, video camera 38 and keypad 42 and driving the display 46 and printer 44.

In use of the apparatus shown in Figures 2 and 3, the user first of all enables the computer, for example by pressing a START key on the keypad, or by entering an access or identification code, or by inserting a credit card into a card reader (which card might allow a predetermined number of uses of the apparatus and is debited by the reader at each time of use). The computer then asks the user, via the display 46, to enter M or F on the keypad (for male or female). Once M or F is entered, the computer asks the user, via the display 46, whether he or she wants a printed profile. When the user enters YES or NO on the keypad, the computer waits.

The user then enters the cubicle and closes the door. If desired the user may remove his or her clothes so as to present a more accurate profile. When ready, the user stands

responds to the signal [illegible]
platform to start its program and also to record the weight of the subject. The computer receives and analyses the video signal from the video camera for a predetermined period of time, then emits an audible tone. This audible tone tells the subject to turn through 90° so that the camera can view the subject in profile. The computer receives and analyses the video signal from the video camera for a further predetermined period of time, then emits another audible tone indicating that the subject may stand down from the platform 36. The subject may then dress and exit from the cubicle.

Meanwhile the computer has determined the weight of the subject from the load cell output and the volume of the subject from the analyses of the video signal. From these results, the computer further determines the density of the subject and (using the formula quoted previously) the body fat %. From a similar formula, the computer also determines the muscle % of the subject.

The computer also determines whether the body fat % is above or below a preferred range. Typically, the preferred range is 11-18% for a male and 15-22% for a female.

The printer then issues a printout which records the date, weight, volume, density, body fat% and muscle %. The printout further states if the body fat % is too high or too low. Optionally the printout may give an indication of how much weight the subject should desirably lose (or gain), and data indicating the rates at which weight might be lost through exercise or dieting e.g. "half hour jogging or brisk walk at 5mph with pulse rate no more than 120 will burn off 2188 calories or fat equivalent to 0.24 kgs. Diet reduction of 437 calories gives a weekly loss of 0.24 kgs. The total loss with diet and exercise could be 0.48 kgs per week". Optionally also the printout can, when the user has requested this on the keypad before entering the cubicle, include a printed profile or

silhouette of the subject, as shown in Figure 5. It will be appreciated that this profile, and also the data for determining the volume of the subject, is obtained from the output signal from the video camera: the signal analysis comprises determining, for each successive line of scan, the portions which receive light direct from the illuminated panel 34 and the portions which are prevented from received such direct light by the intervening subject, and then determines the area and position of the image formed by the subject at the video camera.

The apparatus and method which have been described are relatively simple and straightforward and inexpensive yet provide measurements reasonably accurately representing body density or percentage of body fat, and without any direct-contact which some subjects might find objectionable.

CLAIMS

1) An apparatus for determining a person's body density or fat level, comprising a light receiving device for directing at a person and means for determining the person's body density or fat level in accordance with the intensity of illumination received by said device.

2) An apparatus as claimed in claim 1, comprising a light-tight cubicle for the subject to enter and including a platform coupled to a load cell and disposed in front of a light source in the form of an illuminated panel.

3) An apparatus as claimed in claim 2, in which the light receiving means comprises a video camera.

4) An apparatus as claimed in claim 3, further comprising a computer receiving the video output signal from the video camera via a digitiser and also receiving the output signal from the load cell.

5) An apparatus as claimed in claim 4, in which the computer is initiated when a signal is received from the load cell indicating that the subject has stood on the platform.

6) An apparatus as claimed in claim 5, in which the computer is arranged to calculate body volume from an analysis of the video output signal when the person is facing the video camera and from an analysis of the video output signal when the person is facing sideways.

7) An apparatus as claimed in claim 6, further comprising a printer for providing a printout giving at least body weight, body volume and body fat %.

8) An apparatus as claimed in claim 6, in which the printout also includes a profile of the subject.

9) A method of determining a person's body density or fat level, comprising directing a light receiving device at a person and determining the person's body density or fat level in accordance with the intensity of illumination received by said device.

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